ADMISSION TO THE SECOND YEAR

DEVELOPMENT OF MEASUREMENT TECHNIQUES OF STRESS-STRAIN STATE OF LIFTING MACHINERY COMPONENTS

Centro Interdipartimentale di Studi e Attività Spaziali «G. Colombo»

Scuola di Dottorato in Scienze Tecnologie e Misure Spaziali (STMS) CICLO XXXIII

Curriculum: Misure Meccaniche per l'Ingegneria e lo Spazio (MMIS)

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Overview of the presentation

- Objectives of the research
- Industry
- Numerical and experimental analysis
- Further development

Objectives of the research

Development of measurement techniques of stress-strain state of lifting machinery components

- To get familiar with issues related to lifting machinery
  - Machinery
  - Tests and legislations
  - Issues
  - Matter of interest
- To apply standard methods and techniques
  - Thermoelasticity
  - Damage evaluation
  - Numerical analysis
  - Experimental analysis
- To develop innovative methods and techniques
  - Algorithms and test bench
  - Laboratory experience
  - Tests on the ground
  - Creating a black box

Industry overview

Industry

TEREX®

Products

- GTH 1544
- GTH 2506
- S60
- S65 (XC)
- GTH 1256
- GTH 3007
- Z33
- Z45
- GTH 4014
- GTH 4018
- Z51
- Z62

Main Issues

Test and Legislations

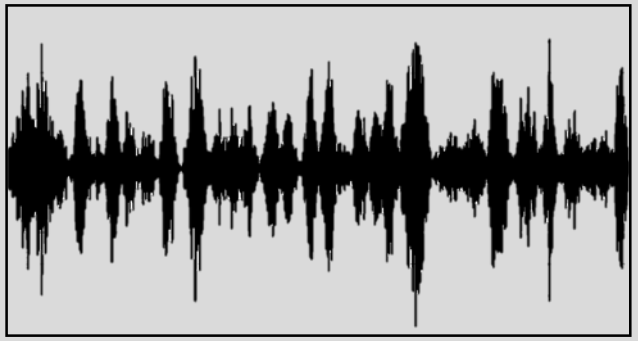
Vibrations

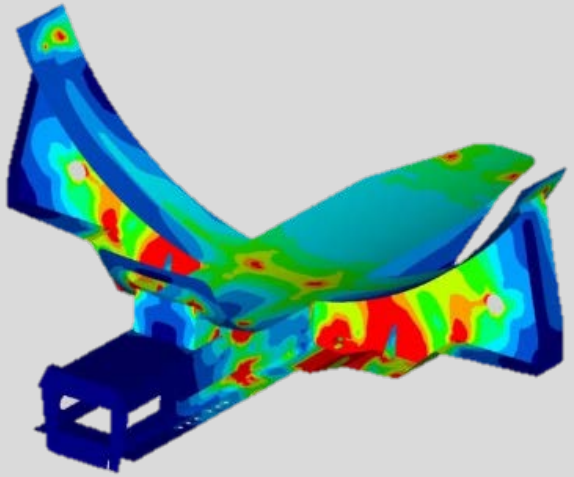
Critical Stress-Strain State

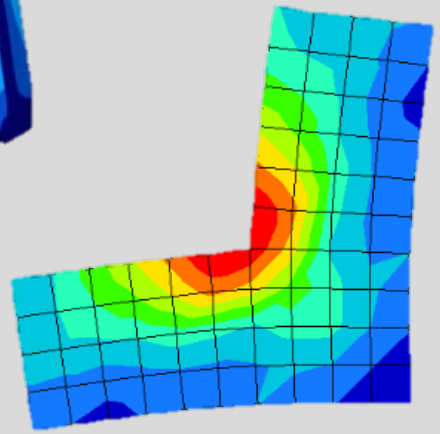
Fatigue Life

Comfort and life quality

Noise







Theoretical Background

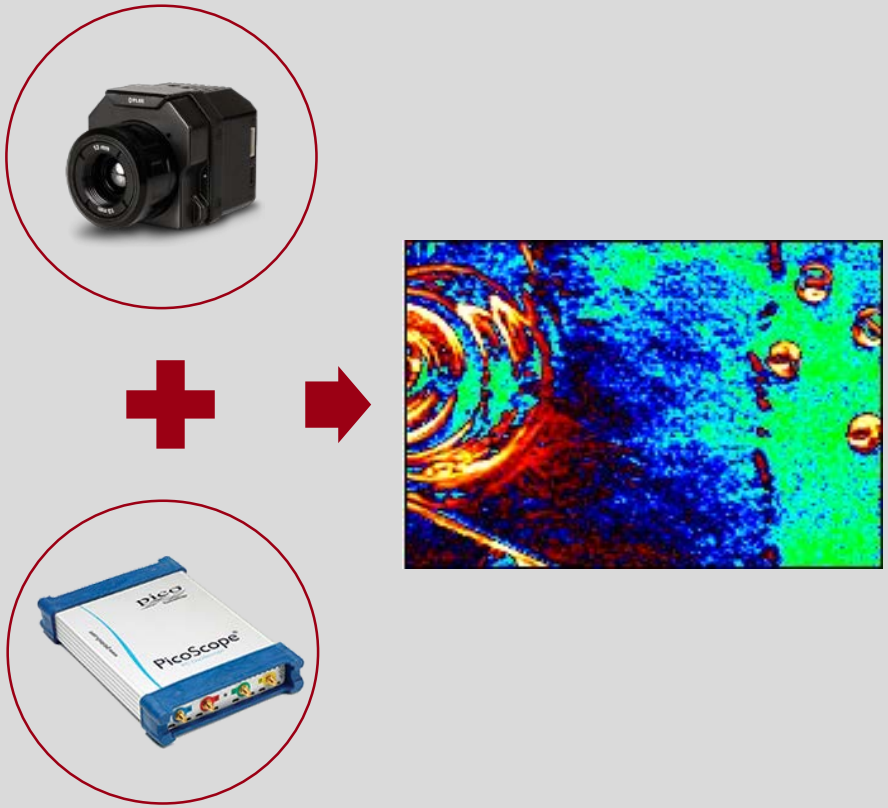
Thermoelastic Stress Analysis

$$\Delta T = \frac{-\alpha\, T}{\rho\, C_p}\ (\,\Delta\sigma_x + \Delta\sigma_y)$$

- α = Thermal expansion coefficient
- C_p = Specific heat
- ρ = Density
- T = Absolute Temperature
- $\Delta\sigma_{i,j}$ = Variation of surface tension in two orthogonal directions lying on the surface

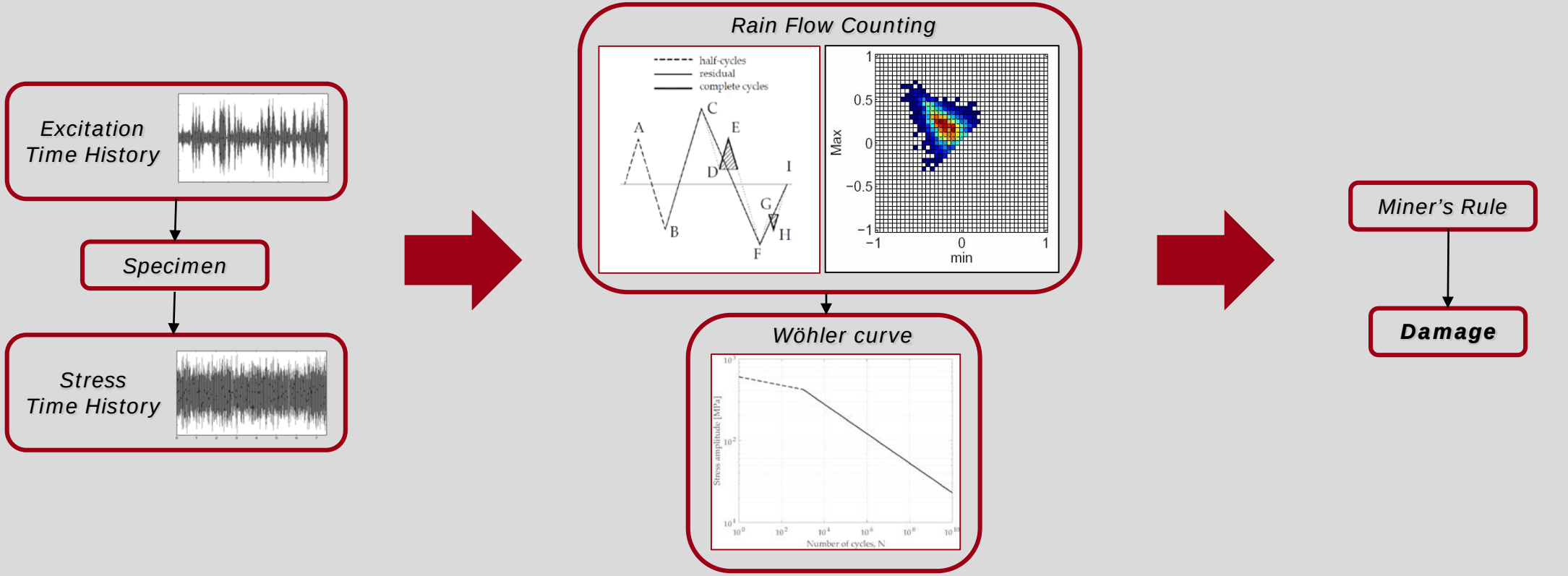
Hypothesis:

- Isotropic, homogeneous and linear elastic behavior
- Adiabatic processes



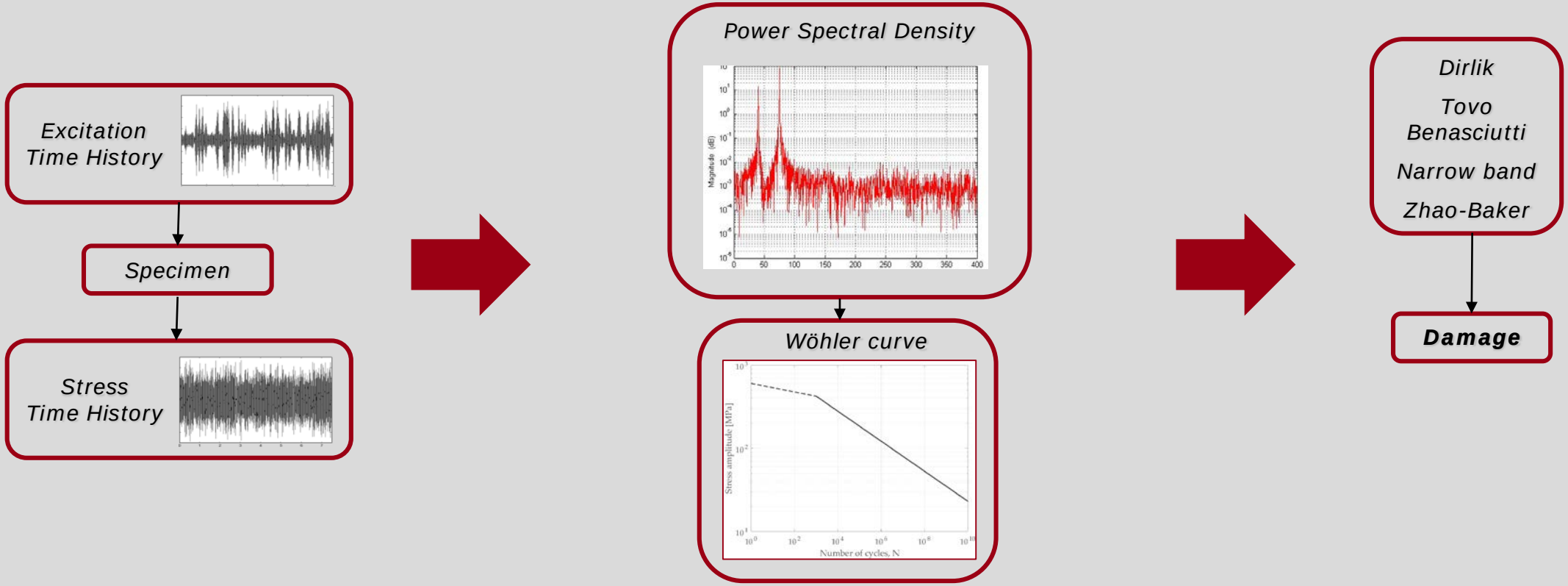
Damage evaluation

Time domain



Damage evaluation

Frequency domain

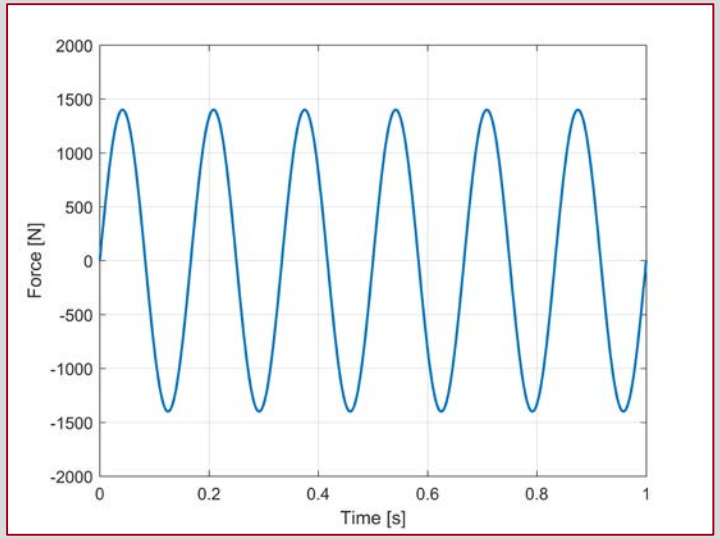


Preliminary Experimental Analysis

Preliminary Experimental Analysis

Terex Genie S-65

Welded area



Vibrodyne Load

Strain Gauge Rosette

$$\begin{cases} \epsilon_{xx} = \epsilon_A \\ \epsilon_{yy} = \frac{1}{3}(2(\epsilon_B + \epsilon_C) - \epsilon_A) \\ \gamma_{XY} = \frac{1}{\sqrt{3}}(\epsilon_C - \epsilon_B) \end{cases}$$

$$\begin{cases} \epsilon_1 = \frac{1}{2}\left(\epsilon_x + \epsilon_y + \sqrt{(\epsilon_x - \epsilon_y)^2 + \gamma_{xy}^2}\right) \\ \epsilon_2 = \frac{1}{2}\left(\epsilon_x + \epsilon_y - \sqrt{(\epsilon_x - \epsilon_y)^2 + \gamma_{xy}^2}\right) \end{cases}$$

$$\begin{cases} \sigma_1 = \frac{E}{1-\nu^2}(\epsilon_1 + \nu\epsilon_2) \\ \sigma_2 = \frac{E}{1-\nu^2}(\epsilon_2 + \nu\epsilon_1) \end{cases}$$

$$K = \frac{\Delta\sigma_x + \Delta\sigma_y}{\Delta T_{avg}}$$

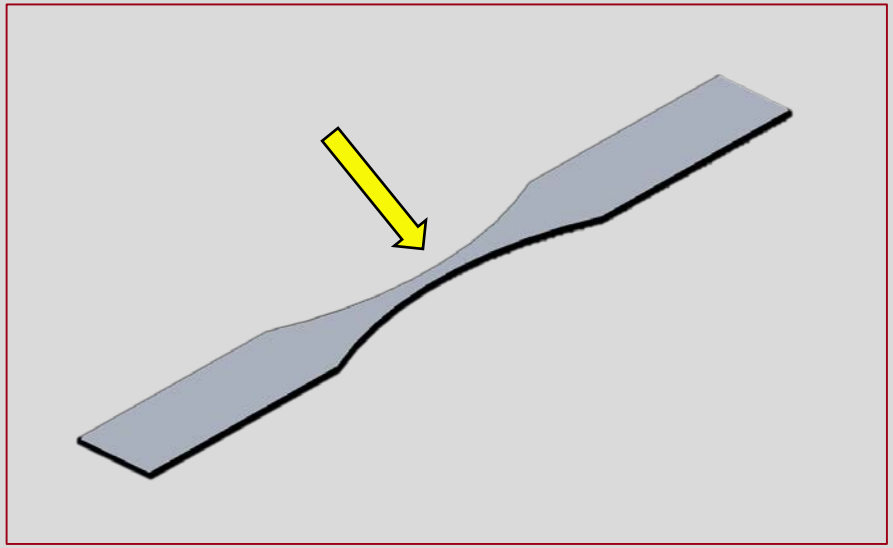
$$K = \frac{\mathrm{E} \cdot (\epsilon_x + \epsilon_y)}{\Delta T_{avg} \cdot (1-\nu)}$$

Stress Map

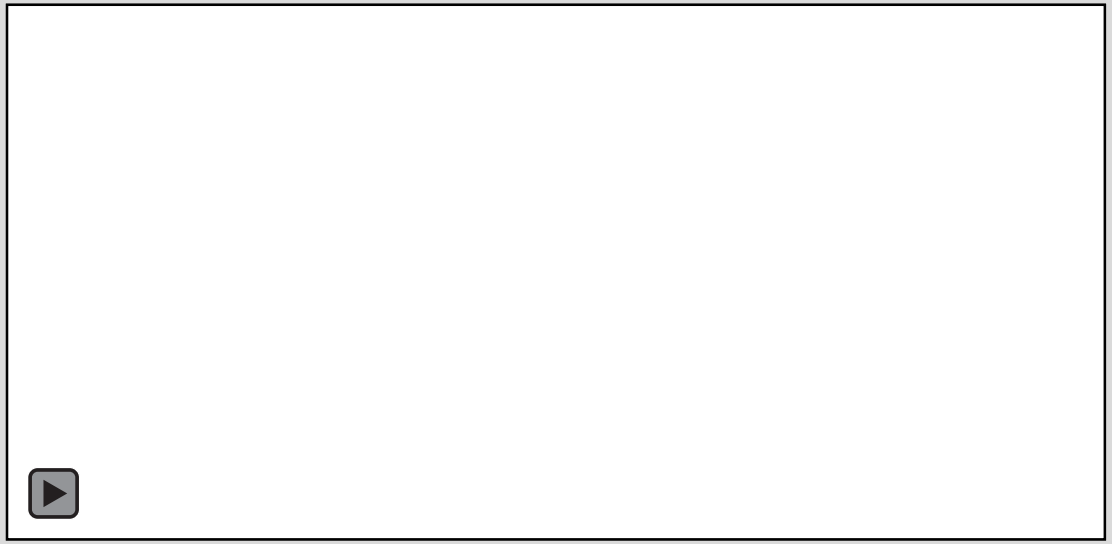
Numerical and Experimental Analysis

Damage evaluation through thermoelasticity

Numerical and Experimental Analysis



Structural Steel Specimen

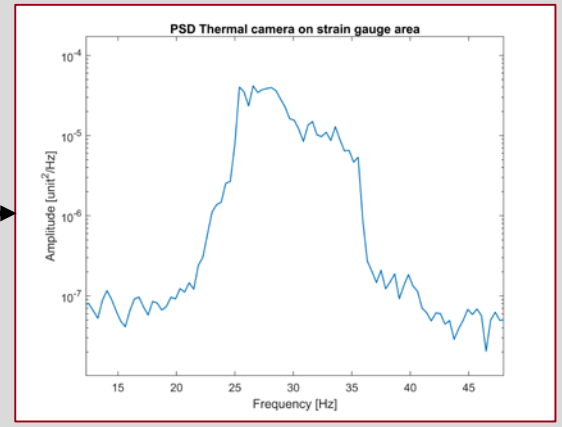


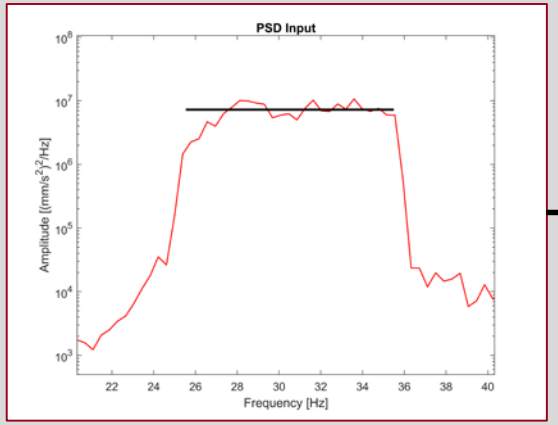
Modal Analysis

Development of measurement techniques of stress-strain state of lifting machinery components

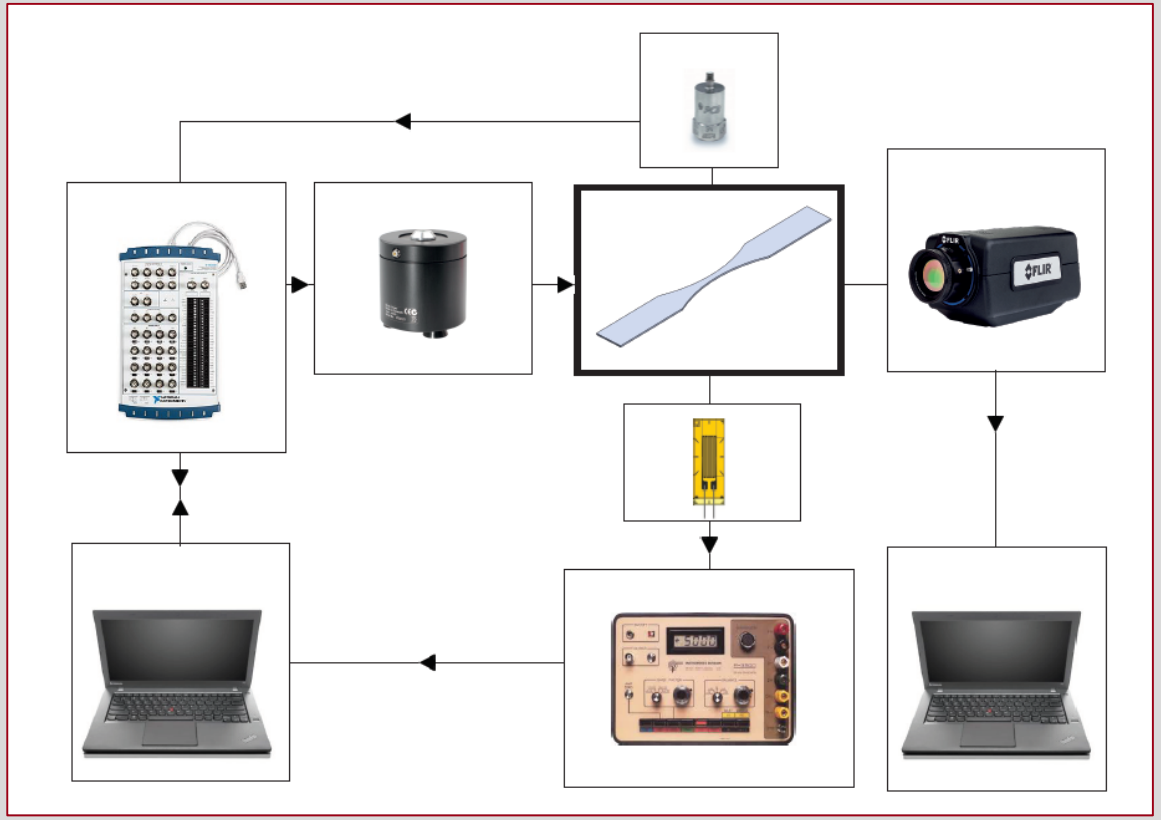
PhD Student: Lorenzo Capponi

PSD Thermal camera

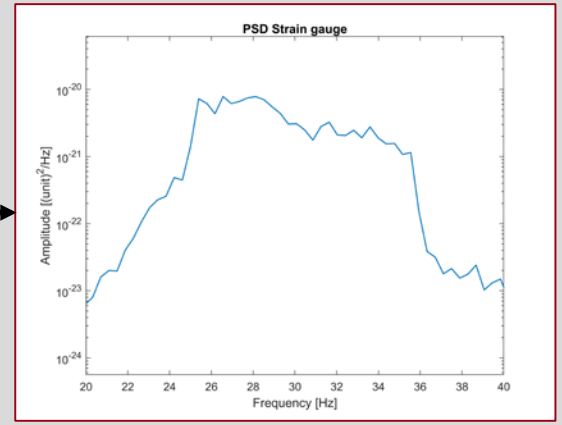




PSD Random Input Excitation

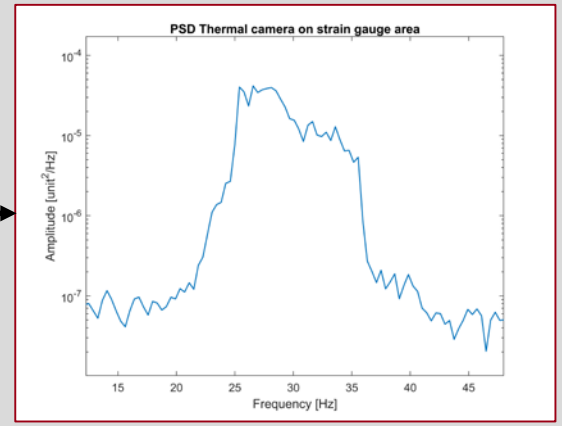


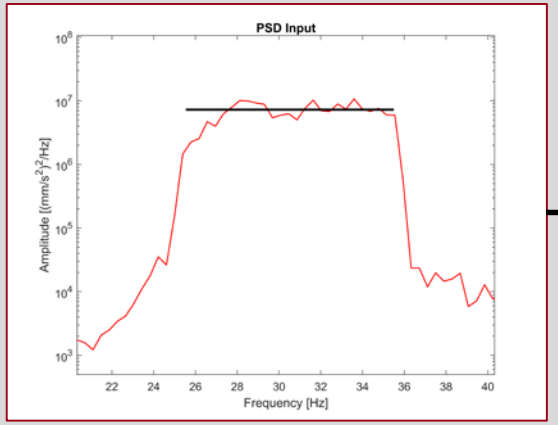
Measurement Chain



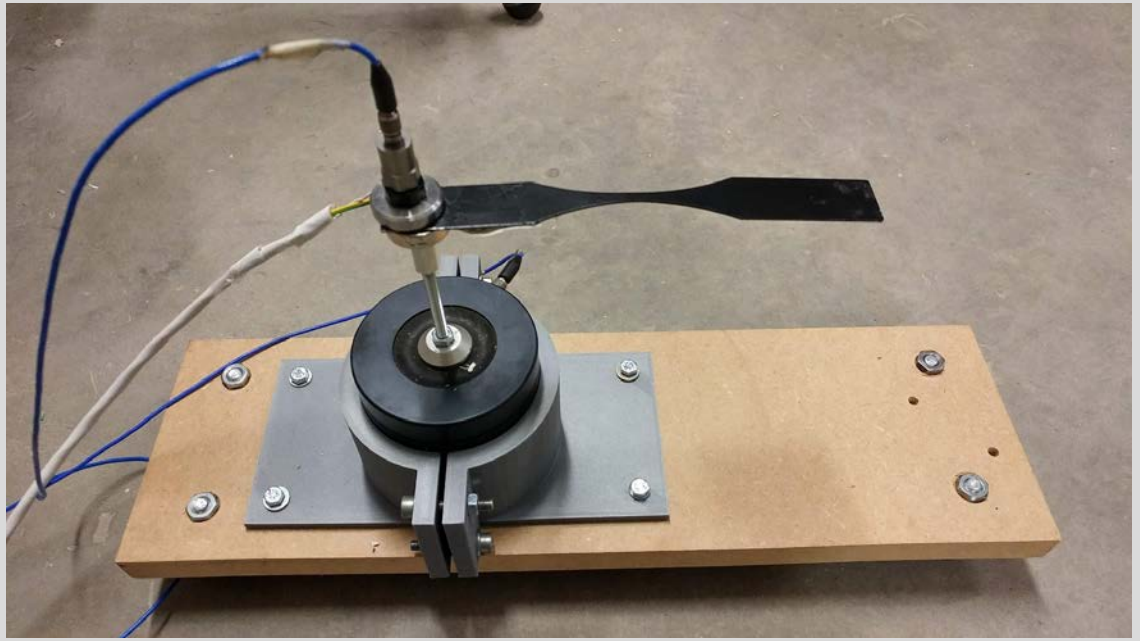
PSD Strain Gauge

PSD Thermal camera

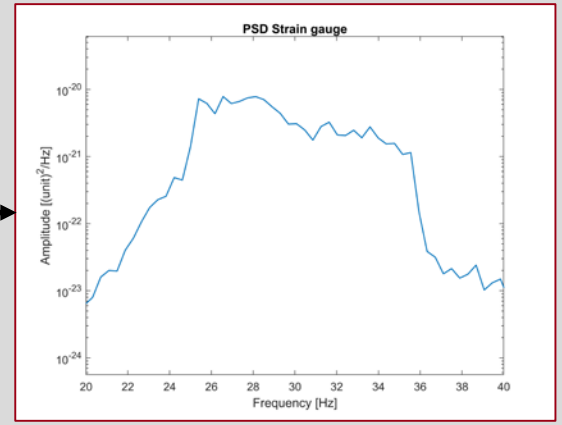




PSD Random Input Excitation



Measurement Chain

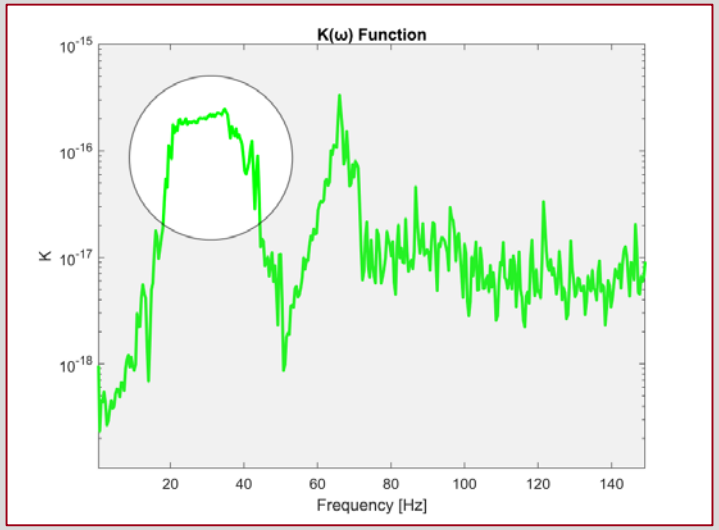


PSD Strain Gauge

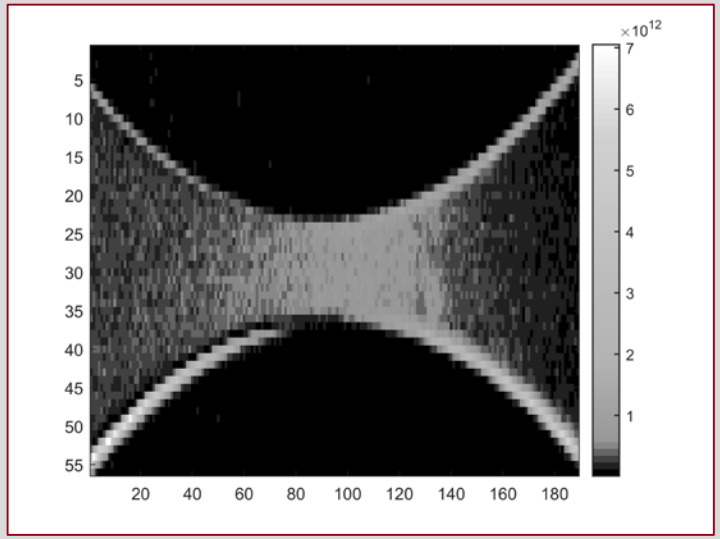
$$\mathrm{K}(\omega) = \frac{PSD\ (Strain\ gauge)}{PSD\ (avg(thermalcamera)_{SG})}$$

$$\Theta(\omega) = \frac{W\ (\omega)}{K(\omega)}$$

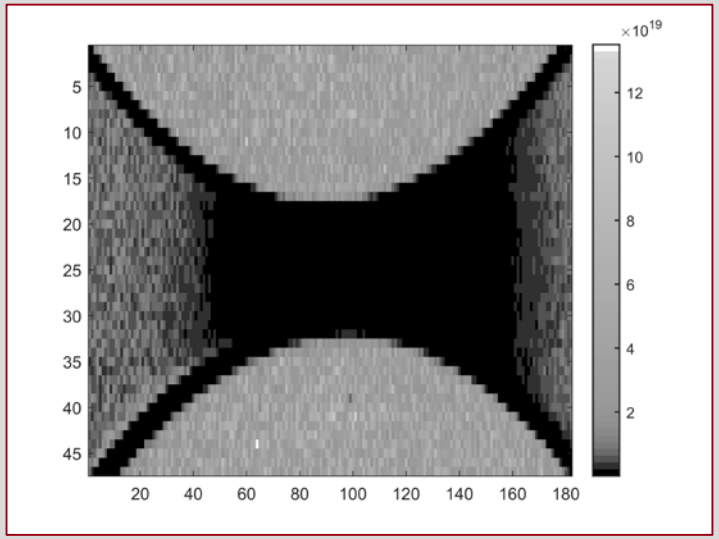
Dirlik Method



K Function



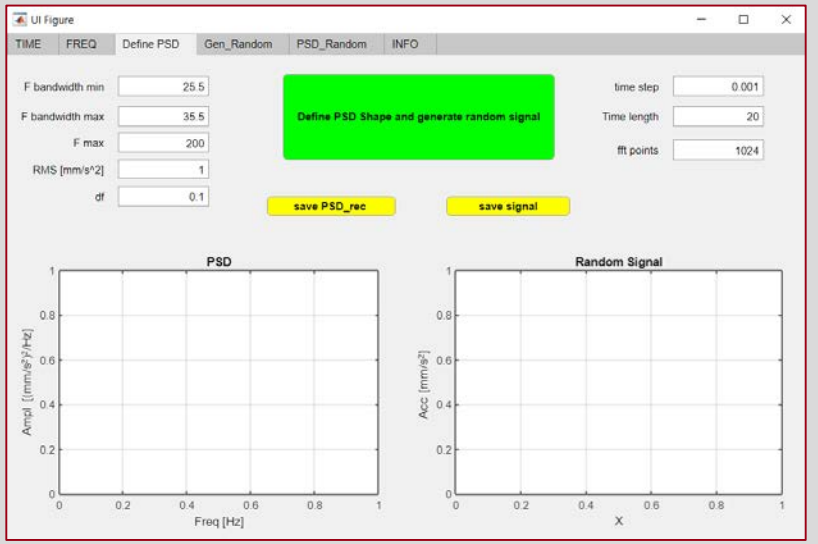
Stress PSD Response
[MPa^2/Hz]



Fatigue Life [s]

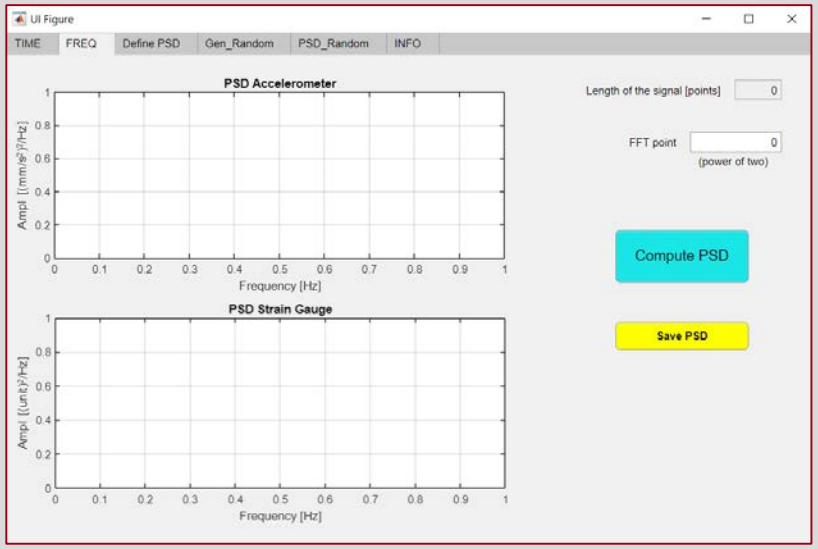
Development of measurement techniques of stress-strain state of lifting machinery components

PhD Student: Lorenzo Capponi

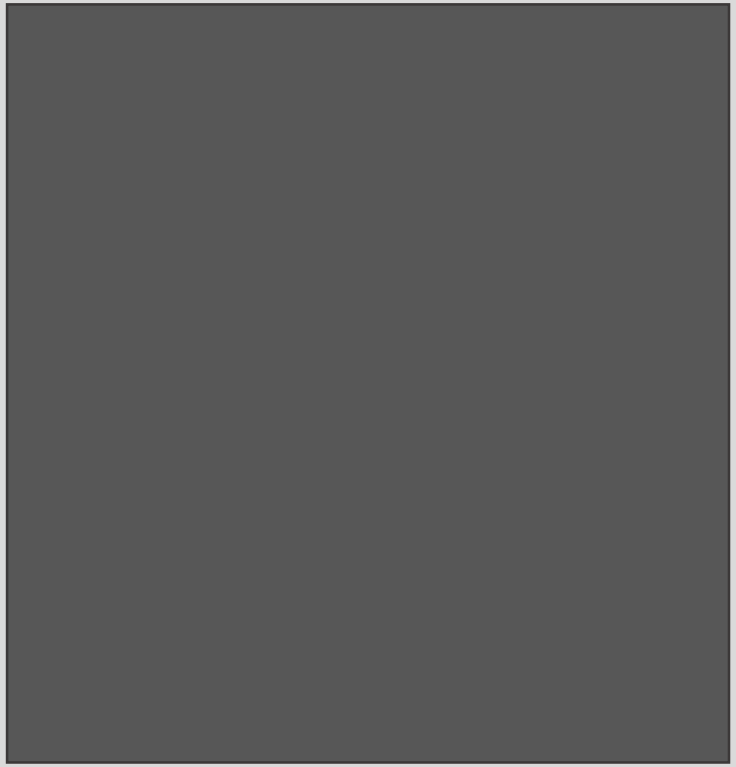


MATLAB

APP DESIGNER



Next steps and further development

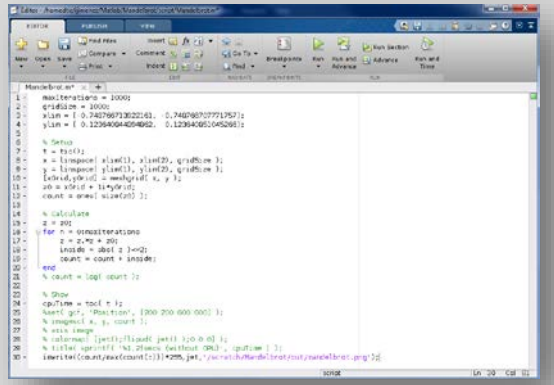


Mounting bracket of front axle

Preliminary FEM Analysis

Next steps and further development

- Application of damage evaluation method to lifting machinery components
- Innovative measurement chain (e.g. GPS, gimbal, drones)
- Software development
- Develop a user friendly package



INPUT
- Thermal Camera
- Strain Gauge
- Material

→ **SYSTEM** →

OUTPUT

Real-time and full-field
- Stress concentration
- Damage evaluation

Thank you for your attention